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US ISSN 0006-9698

CAMBRIDGE, MASS.

19 JANUARY 2018

NUMBER 557

## ON THE STATUS OF *CYRTODACTYLUS MALCOLMSMITHI* (CONSTABLE, 1949)

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**ABSTRACT.** *Cyrtodactylus malcolmsmithi* was described by Constable in 1949 in the genus *Gymnodactylus* on the basis of its apparently undivided subdigital lamellae. The species has not been collected since and only finds mention in some checklists and new *Cyrtodactylus* descriptions. We recently examined the holotype and paratype of this enigmatic taxon and discovered that the subdigital lamellae are divided. The species is accordingly transferred to the genus *Hemidactylus*, within which it is a member of the *Hemidactylus brookii* complex and a valid species, *Hemidactylus malcolmsmithi* comb. nov. We assign recently sampled populations to this taxon and provide a diagnosis against congeners from the Indian subcontinent and a summary of characters for the species.

**KEY WORDS:** Gekkonidae; *Hemidactylus*; *Hemidactylus brookii* complex; *Hemidactylus malcolmsmithi*; India; South Asia

### INTRODUCTION

The single largest contributor of Indian reptile specimens to the Museum of Comparative Zoology, Harvard (MCZ) was M. M. Carleton (1826–1898), an American Presbyterian minister who moved to India in 1854, collecting in northern India in what are today the states of Punjab, Haryana, and Himachal Pradesh (Anonymous, 1898).

Two-hundred thirty reptile specimens were contributed by Carleton between 1871 and 1880 (Constable, 1949), which include 108 of the 370 Indian lizard specimens at the MCZ (<http://mczbase.mcz.harvard.edu>). Constable (1949) reviewed the Indian reptiles in the collections of the MCZ, describing a new gecko, *Gymnodactylus malcolmsmithi* Constable, 1949, on the basis of two specimens from northern India collected by Carleton. He described the poorly preserved specimens as "swollen and macerated" and found it difficult to determine the condition of the subdigital lamellae, remarking that the digits were moderately dilated with indications of a few divided lamellae in the holotype. Constable (1949) followed the opinion of Mal-

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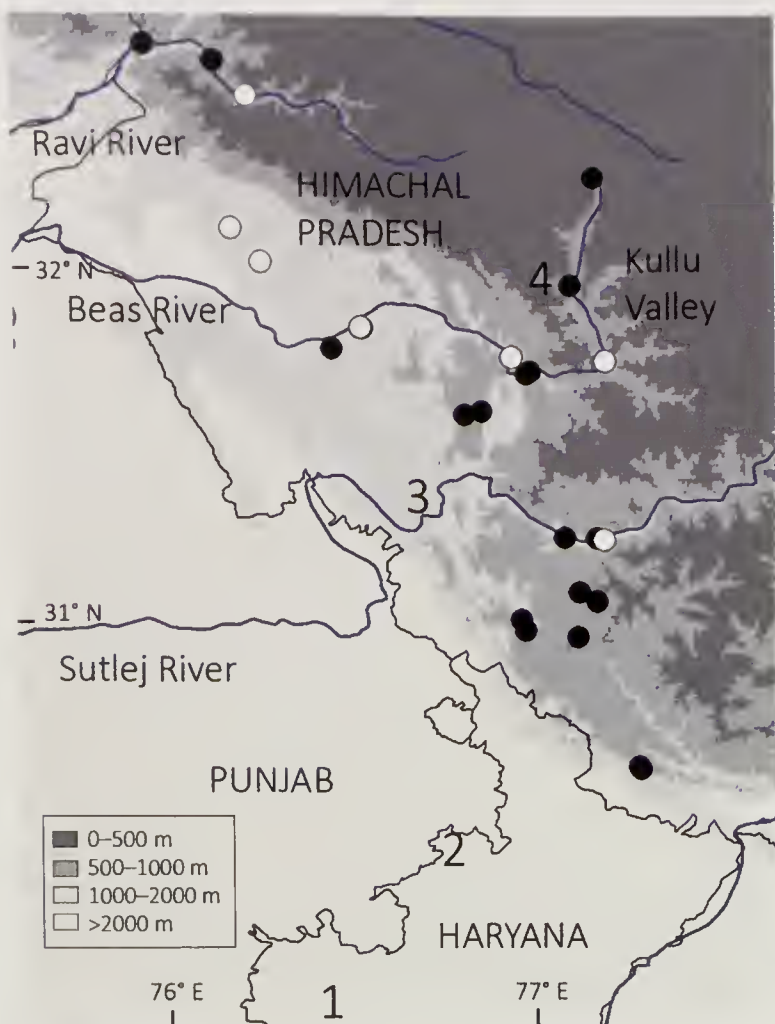


Figure 1. Elevation map of northern India showing sampling localities in the Himalayas (circles) and localities for *Hemidactylus malcolmsmithi* (white circles), with numbers depicting Carleton's specific northern Indian localities (1, 70 km SW of Ambala; 2, Ambala; 3, Bilaspur; 4, Kullu). Major rivers are marked, administrative divisions (States) are in caps, and the Kullu Valley is labeled.

colm Smith and Arthur Loveridge and described the new species in the genus *Gymnodactylus* Spix, 1825, characterized by undivided, nonadhesive subdigital lamellae. However, indicative of how difficult it was to determine the lamellar condition in these poorly preserved specimens, Constable (1949) also included diagnoses of the new species against *Hemidactylus* species (which are characterized by dilated digits and divided subdigital lamellae).

Since its original description, aside from being transferred to *Cyrtodactylus* Gray, 1827 along with other Old World '*Gymnodactylus*' with vertical pupils (Underwood,

1954), *Cyrtodactylus malcolmsmithi* has only been included in some checklists (e.g., Kluge 1991, 1993, 2001; Rösler 2000; Bauer et al., 2013; and misspelled as *C. malcomsmithi* in Venugopal, 2010) or as part of comparisons in new species descriptions (e.g., Bauer et al., 2009). The enigmatic *C. malcolmsmithi* remains the only mainland Indian bent-toed gecko not to have been recently collected, despite targeted surveys by us around its imprecise type locality (Fig. 1). *Cyrtodactylus malcolmsmithi* has remained a taxonomic mystery since, with the peculiar condition of the digits and relatively poor state of preservation preventing unambiguous generic allocation.

A re-examination of the types of *C. malcolmsmithi* revealed that the digits are in fact divided, in conjunction with other morphological characters suggesting the species is a member of the *Hemidactylus brookii* Gray, 1845 complex. We transfer this species to *Hemidactylus* and demonstrate that it is a valid species within the genus, also providing a brief overview of the taxonomic history of the *H. brookii* complex.

## MATERIALS AND METHODS

### Morphology

We took measurements on the right side of the body using a digital caliper rounded to the nearest 0.1 mm on the holotype and paratype of *C. malcolmsmithi*. We recorded snout-to-vent length (SVL), trunk length (TRL), body width (BW), tail length (TL), width of tail base (TW), head length (HL), head width (HW), head height (HH), forearm length (FL), crus length (CL), widest diameter of eye (ED), nostril to eye distance (NE), snout to eye (SE), eye to ear (EE), and interorbital distance (IO, measured at the anterior of the orbit). We also counted femoral pores (FP), the number of poreless

scales separating the femoral pores (SFP), the number of dorsal tubercle rows (DTR), supralabials (SL), infralabials (IL), and subdigital lamellae (under the first and fourth fingers, F1, F4 and the first and fourth toes, T1, T4). As the types are soft and in poor condition we were not able to take all data from both specimens. Digits were examined submerged in ethanol to allow the lamellae, which are longitudinally folded over upon themselves when not in fluid, to float freely and be manipulated.

We also compared the types of *C. malcolmsmithi* with published data and specimens of the *H. brookii* complex and Indian *Hemidactylus* from Agarwal et al. (2011), Mahony (2011), and Lajmi et al. (2016). Museum abbreviations are as follows: CES, Centre for Ecological Sciences, Bangalore, India; MCZ, Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, U.S.A.; NCBS, National Centre for Biological Sciences, Bangalore, India.

#### Retracing Carleton's collecting sites

Carleton's collections had generally good locality information and were largely made in a small area of northern India between Ambala, Haryana, and Kullu, Himachal Pradesh (though some other reptiles and amphibians collected by Carleton are from "Bengal" and "northern India"). Unfortunately, neither specimen of *C. malcolmsmithi* has precise locality information; the holotype is from the "Beas River basin, Punjab, India" and the paratype from the "Kullu Valley, Punjab, India." (Constable, 1949). We sampled for the species in the vicinity of these imprecise localities in 2011 (Fig. 1), looking for a *Cyrtodactylus* that matched Constable's (1949) description. We sampled across elevations below 2,000 m in the Kullu Valley and Beas River basin and the only

*Cyrtodactylus* we recorded from those areas were allied to *C. fasciolatus* (Blyth, 1861) and *C. lawderanus* (Stoliczka, 1871). The only other geckos found were *Hemidactylus flaviviridis* Rüppel, 1835 and a member of the *H. brookii* complex.

#### RESULTS

Mensural and meristic data for the holotype and paratype of *C. malcolmsmithi* are summarized in Table 1. Strikingly, both the holotype and paratype of *C. malcolmsmithi* have divided lamellae (Fig. 2), which can only be discerned with some manipulation in liquid under high magnification. In light of this new information and morphological data from the types, we transfer the species to the genus *Hemidactylus*. The types can be assigned to the *H. brookii* complex on the basis of their small body size, number and condition of femoral pores, and dorsal tuberculation (Table 1; Lajmi et al., 2016).

The *H. brookii* complex is one of the most taxonomically challenging groups in the genus, including as many as nine synonyms until as recently as 2010 and numerous undescribed taxa (Bauer et al., 2010b; Mahony, 2011; Lajmi et al., 2016). Recent phylogenies revealed several divergent clades within the *H. brookii* complex, with existing names tentatively assigned to some clades (Bansal and Karanth, 2010; Bauer et al., 2010a, b; Kathriner et al., 2014; Lajmi et al., 2016), though it remains unclear if true *H. brookii* has been sampled since its original description (Mahony, 2011; Lajmi et al., 2016). This taxonomic instability has been exacerbated by the fact that many of the species within this group are anthropophilic, with human-mediated dispersal obscuring natural distributional ranges (Bansal and Karanth, 2010; Bauer et al., 2010a, b; Kathriner et al., 2014; Lajmi et al., 2016). *Hemidactylus brookii sensu stricto* is likely a

TABLE 1. MENSURAL AND MERISTIC DATA FOR THE TYPES OF *HEMIDACTYLUS MALCOLMSMITHI* AND OTHER MATERIAL REFERRED TO THE SPECIES. ABBREVIATIONS AS IN MATERIALS AND METHODS.

Specimen no.	Sex	(L,R)	SFP	DTR	F1	F4	T1	T4	SL	IL	SVL	TRL	BW	CL	TL	TW	HL	HW	HH	FL	ED	NE	SE	EE	IO	FP
Holotype	M	12,12	2	20	—	—	—	~9	11	10	53.7	25.4	11.5	7.8	53.5*	5.3	14.3	10.3	5.3	7.2	3.4	5.2	6.2	4.4	4.8	
MCZ-R-3252																										
Paratype	F	0	NA	16	—	—	—	—	11	8	36.2	16.7	6.9	—	44.2	4.0	10.6	6.9	4.4	—	—	—	—	—	—	
MCZ-R-4335																										
CES09004	M	12,11	2	16-18	6(3)	7	5	10	10	9	52.8	23	12	8	12.5*	4.9	15.5	11.1	6.5	7	2.7	5	6.3	5	5.3	
CES09058	M	11,11	2	16-19	6(3)	8(2)	6(3)	10(4)	9	9	46.8	19.1	10.7	7.2	27.9*	4.5	13.5	9.4	5.7	6.6	2.7	4.4	5.7	4	4.5	
CES11051	F	0		14-16	5(2)	7(1)	6(3)	9(3)	9	6	43	21.9	11	7.2	18.8*	4.3	13.5	9	5.2	6.5	2.7	4.5	5.7	4.3	4.5	
CES11052	M	12,12	2	18-20	6(3)	8(3)	6(3)	11(5)	11	8	53.8	22.4	11.5	8.1	8.4	5.1	15	10.5	5.7	7.5	2.7	5	6.4	5	5.5	
CES11054	M	14,14	2	18-20	6	8	6(3)	10(3)	10	8	42.5	18.5	9.3	7.2	15*	3.8	12.4	8	4.6	5.5	2.7	3.9	5.2	3.6	4.2	
CES11055	M	11,11	1	13-15	5	7	4	9	10	7	50.3	21.9	10.2	7	20.5	5	14.5	9.8	5.5	7.1	2.7	4.6	6	4.4	4.6	
CES11057	M	13,12	2	14-15	6	7	5	9	9	8	54.2	24	11.8	8.3	23.8*	5.8	15.7	10.9	6	7.8	2.7	5.2	6.6	5.1	5	
CES11059	M	12,12	3	15-16	6	7	5	9	9	8	51.5	23.2	11.4	7.6	22*	4	14.5	10.3	5.7	6.8	2.7	5.1	6.3	4.4	4.5	
CES11065	M	12,10	2	15-16	6	8	5	10(3)	9	8	42.4	16.8	8.3	6.3	50	3.5	12	8.1	4.4	5.8	2.7	4	5.1	4	4	
CES11070	F	0	NA	17-18	6(3)	7(2)	6(4)	10(4)	10	7	52.8	21.7	11.6	7.5	50	4.7	14.4	10	5.4	7.2	2.7	4.6	5.9	4.6	5	
CES11072	M	11,12	3	15-16	6	8	6	9	9	7	53.5	21.7	10.7	7.5	65	5.7	15.7	11.4	6.2	7	2.7	5	6.5	5	5.3	
CES11073	M	11,10	3	15-16	6(2)	7(1)	6(3)	10(4)	10	8	43.5	18.3	9.8	7.1	13.5*	3*	12.4	8.6	4.5	5.9	2.7	4.1	5.2	3.7	4.3	

\*Indicates tail regenerated.

NA, not applicable.



Figure 2. View of left manus of *Hemidactylus malcolmsmithi* (left panel, CES/11/052 in life; right panel, holotype MCZ-R-3252).

member of the *brookii* group (Bauer et al., 2010a) or the equivalent tropical Asian clade 1 (Bansal and Karanth, 2010; but see Mahony, 2011 for a consideration that populations in Borneo may have originated from multiple colonizations or from Africa), and the most comprehensively sampled phylogeny from the Indian subcontinent recovered seven divergent clades within the *H. brookii* complex (Lajmi et al., 2016). Apart from the ground-dwelling clade, which includes five morphologically distinct described species, the *H. brookii* complex includes *H. murrayi* Gleadow, 1887, *H. parvimaclatus* Deraniyagala, 1953, *H. treutleri* Mahony, 2009, one clade that is morphologically most similar to *H. gleadowi* Murray, 1884, and two clades allied to *H. kushmorensis* Murray, 1884 (clade 2 and clade 3 *H. cf. kushmorensis*; Lajmi et al., 2016). The type localities of *H. gleadowi*, *H. kushmorensis*, *H. murrayi*, and an *H. brookii* synonym of uncertain status, *H. mahendrai* Shukla, 1983, are all in the northern region of the subcontinent. The distribution of clade 3 *H. cf. kushmorensis* of Lajmi et al.

(2016) is largely in the Himalayan foothills and overlaps extensively with the Kullu Valley and Beas River basin (Fig. 1).

On the basis of the morphological, meristic, and distributional data at hand, we consider the types of *C. malcolmsmithi* to be conspecific with the geckos comprising clade 3 *H. cf. kushmorensis* of Lajmi et al. (2016) (Table 1), and here define and diagnose *H. malcolmsmithi* comb. nov.

#### Systematics

*Hemidactylus malcolmsmithi* comb. nov.

Figures 2–4

*Gymnodactylus malcolmsmithi* Constable, 1949

*Cyrtodactylus malcolmsmithi* Underwood, 1954

*Holotype*. MCZ-R-3252. Adult male, “Beas Riv. Basin” (= Beas River basin, includes parts of Himachal Pradesh and Punjab, India), collected by M. M. Carleton, 1872.

*Paratype*. MCZ-R-4335. Subadult male, “Kooloo Valley” (= Kullu Valley, Himachal

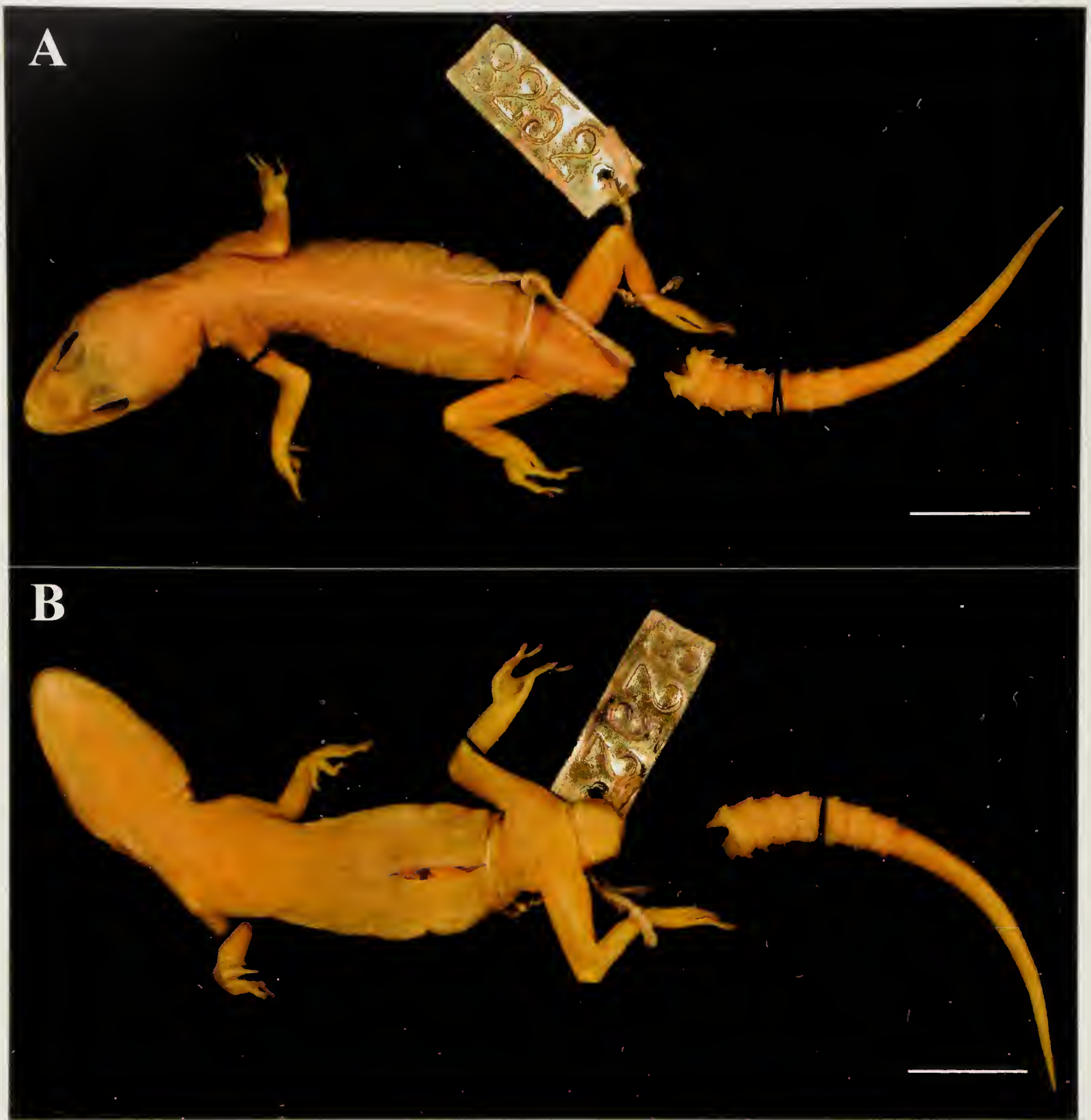


Figure 3. Dorsum (top panel) and venter (bottom panel) of *Hemidactylus malcolmsmithi* (holotype MCZ-R-3252). Photo credit: Museum of Comparative Zoology, Harvard University.

Pradesh, India) collected by M. M. Carleton, 1871.

*Referred Material.* CES09004, adult male, Baripada, Odisha ( $21^{\circ}56'10.3194''\text{N}$ ,  $86^{\circ}44'4.1994''\text{E}$ ); CES09058, adult male, Ajmer, Rajasthan ( $26^{\circ}26'27.9594''\text{N}$ ,  $74^{\circ}45'52.56''\text{E}$ ); CES11051, adult female,

near Tattapani, Himachal Pradesh ( $31^{\circ}14'30.48''\text{N}$ ,  $77^{\circ}12'8.2794''\text{E}$ ); CES11052, adult male, near Jhiri, Himachal Pradesh ( $31^{\circ}44'31.2''\text{N}$ ,  $77^{\circ}12'28.08''\text{E}$ ); CES11054, adult male, Mandi-Kullu road, Himachal Pradesh ( $31^{\circ}45'21.9594''\text{N}$ ,  $76^{\circ}56'36.6''\text{E}$ ); CES11055, CES11057, CES11059, adult



Figure 4. *Hemidactylus malcolmsmithi* in life (CES/11/050).

males, Kangra-Jwalamukhi Road, Himachal Pradesh ( $32^{\circ}1'10.92''\text{N}$ ,  $76^{\circ}14'43.44''\text{E}$ ); CES11065, Sujampur, adult male, Himachal Pradesh ( $31^{\circ}50'14.2794''\text{N}$ ,  $76^{\circ}31'13.7994''\text{E}$ ); CES11070, adult female, near Lunj, Himachal Pradesh ( $32^{\circ}6'39.96''\text{N}$ ,  $76^{\circ}9'40.3194''\text{E}$ ); CES11072, adult male, Chamba, Himachal Pradesh ( $32^{\circ}28'35.7594''\text{N}$ ,  $76^{\circ}12'38.88''\text{E}$ ); CES11073, adult male, Reasi, Jammu ( $33^{\circ}4'41.8794''\text{N}$ ,  $74^{\circ}49'52.6794''\text{E}$ ). All localities in India.

*Definition.* A small-sized *Hemidactylus*, snout-vent to 54 mm. Dorsal pholidosis heterogeneous, composed of granular scales intermixed with 15–20 longitudinal rows of slightly enlarged, keeled, conical tubercles at midbody. Two pairs of postmentals, the inner pair much larger than the outer pair and only in contact with supralabial 1. Ventrolateral folds indistinct, 34–36 scale

rows across venter. All digits with enlarged scapors, 7–8 (manus) and 9–11 (pes) lamellae beneath fourth digit and 5–6 (manus) and 4–6 (pes) beneath first digit, with up to five undivided lamellae and a few undivided lamellae under most digits; 10–14 femoral pores on each side separated by one to three (usually two) poreless scales in males. Original tail slightly flattened; scales on tail dorsum heterogenous, slightly larger than granular scales on dorsum, weakly imbricate, intermixed with a longitudinal series of six enlarged, pointed tubercles. Dorsal coloration faded brown with a longitudinal series of small, irregular, dark blotches arranged mainly on either side of midvertebral region, venter uniform white. In life, dorsum with additional indistinct lighter markings.

*Diagnosis.* *Hemidactylus malcolmsmithi* can be distinguished from many other

congeners from India and Pakistan on the basis of its heterogenous dorsal pholidosis that consists of small granules intermixed with 15–20 longitudinal rows of slightly enlarged, keeled, conical tubercles at mid-body. This includes *H. imbricatus* Bauer et al., 2008 and *H. scabriceps* (Annandale, 1906), which have homogenous dorsal pholidosis of imbricate scales without tubercles; the smooth-bodied species *H. aquilonius* McMahan and Zug, 2007, *H. garnotii* Duméril and Bibron, 1836, and *H. platyrus* (Schneider, 1792), with homogeneous dorsal pholidosis of small granules without tubercles; *H. frenatus* Duméril and Bibron, 1836, *H. leschenaultii* Duméril & Bibron, 1836, and *H. flaviviridis* Rüppel, 1835, which either lack tubercles entirely or have a few small rounded tubercles toward the flanks; and *H. lankae* Deraniyagala, 1953 and *H. triedrus* (Daudin, 1802), which have enlarged, strongly keeled, and trihedral tubercles forming more-or-less regular longitudinal rows.

The small size of *H. malcolmsmithi* (SVL up to 54 mm) distinguishes it from several large-bodied species that approach or exceed 90 mm SVL: *H. aaronbaueri* Giri, 2008, *H. acanthopholis* Mirza and Sanap, 2014, *H. giganteus* Stoliczka, 1871, *H. graniticulus* Agarwal et al., 2011, *H. hemchandrai* Dandge and Tiple, *H. maculatus* Duméril and Bibron, 1836, *H. prashadi* Smith, 1935, and *H. yajurvedi* Murthy et al., 2015.

*Hemidactylus malcolmsmithi* may be diagnosed by the condition of the femoral pores (10–14 femoral pores on each side separated by two poreless scales) from the following species: *H. albofasciatus* Grandison & Soman, 1963, *H. gracilis* Blanford, 1870, *H. persicus* Anderson, 1872, *H. reticulatus* Beddome, 1870, *H. robustus* Heyden, 1827, and *H. sataraisensis* Giri & Bauer, 2008, which all have only precloacal pores; and *H. gujaratensis* Giri et al., 2009 which has four or

fewer poreless scales separating the two series of femoral pores.

Within the *H. brookii* complex, *H. malcolmsmithi* can be diagnosed by its heterogenous dorsal pholidosis of small granules intermixed with slightly enlarged, keeled, conical tubercles from *H. gleadowi*, which has trihedral or subtrihedral enlarged tubercles; the condition of the femoral pores (10–14 femoral pores on each side separated by two [range one to three] poreless scales from *H. chipkali* Mirza and Raju, 2017, *H. murrayi*, and *H. treutleri*, which have four or fewer poreless scales separating the two series of femoral pores; by the presence of three to five undivided subdigital lamellae under toe 4 and the extent of the subdigital lamellae (extending till base of sole) from *H. parvimaculatus* (one to three undivided subdigital lamellae under toe 4, enlarged subdigital lamellae do not extend till base of sole); and by the size of the one to three poreless scales separating the femoral pores (subequal to pore-bearing scales) from *H. brookii* (one poreless scale, less than half the size of pore-bearing scales). *Hemidactylus malcolmsmithi* is most similar to *H. kushmorisensis*, from which it can be diagnosed by the condition of the inner postmentals, which are similar in size to and in broad contact with the first infralabials, the outer postmentals either excluded from or just in contact with the first infralabials (vs. inner postmentals much narrower than first infralabials, inner and outer postmentals in broad contact with first infralabials).

*Natural History and Distribution.* *Hemidactylus malcolmsmithi* is nocturnal and may be seen on the ground as well as low rocks, road cuttings, and buildings at night. The species is known from across the lowlands of Himachal and Jammu (up to about 1,500 m), and from a few specimens from Odisha and Rajasthan (Lajmi et al., 2016), though it is unclear what the native range of this species



is, and which, if any, of these localities represent human translocations, with further sampling needed to determine its distributional range.

## DISCUSSION

The status of the enigmatic taxon *H. malcolmsmithi* is finally resolved, through a combination of relatively recent field sampling, a careful examination of >140-year-old museum specimens, and recent publications on the *H. brookii* complex (Mahony, 2011; Lajmi et al. 2016). Constable initially did think he had a *Hemidactylus* before him, but the poor condition of the specimens and the opinions of two experts led him to place the species in *Gymnodactylus*. Interestingly, Khan (2010) opined that this species might be a misidentified specimen of *H. brookii*, and I.A. thought he might have this species when collecting *Hemidactylus* from around the Beas River basin (which we now know are in fact *H. malcolmsmithi*). However, the appearance of the lamellae in the types, which are longitudinally folded over themselves, had led previous researchers to erroneous conclusions.

The taxonomic actions in this paper bring the total number of recognized species of Indian *Hemidactylus* to 32 and drop the non-*Geckoella* mainland Indian *Cyrtodactylus* to five. As currently understood, the *H. brookii* complex includes eight valid species: *H. brookii* Gray, 1845, *H. chipkali* Mirza and Raju 2017, *H. gleadowi* Murray, 1884, *H. kushmorensis* Murray, 1884, *H. malcolmsmithi* (Constable, 1949), *H. murrayi* Gleadow, 1887, *H. parvimaculatus* Deraniyagala, 1953, and *H. treutleri* Mahony, 2009; four names in the synonymy of *H. murrayi*: *Gecko tytleri* Tytler “1864” 1865, *Hemidactylus tenkatei* Lidth de Jeude, 1895, *Hemidactylus subtri-droides* Annandale, 1905, and *Hemidactylus*

*hizonensis* Taylor, 1915. *Hemidactylus mahendrai* Shukla, 1983 has been considered a synonym of *H. brookii* (Mahony, 2011; Lajmi et al., 2016; Mirza and Raju, 2017), but we regard *H. mahendrai* as *incertae sedis* within the *H. brookii* complex. *Hemidactylus brookii*, *H. gleadowi*, and *H. kushmorensis* are known only from their type specimens (though clade 2 *H. cf. kushmorensis* of Lajmi et al., 2016 may be true *H. kushmorensis*); *H. chipkali*, *H. malcolmsmithi*, *H. murrayi*, *H. parvimaculatus*, and *H. treutleri* are all known from wild populations, with extant type material for all except *H. murrayi* (although topotypical material has been sampled; Lajmi et al., 2016).

Wild populations of *H. brookii*, *H. gleadowi*, and *H. kushmorensis* need to be identified and included in phylogenies as a final step toward resolving the status of valid species within the complex. Additionally, thorough sampling across both natural and human-dominated habitats in the Indian subcontinent and molecular and morphological data are needed to understand the diversity and distribution of species within the *H. brookii* complex.

## ACKNOWLEDGMENTS

For facilitating access to the collections and photographs at the MCZ, we thank José Rosado, Tsuyoshi Takahashi, Joe Martinez, James Hanken, Jonathan Losos, and Linda Ford. Jonathan DeBoer helped examine and photograph specimens. A.M.B. and I.A. were partly supported by U.S. National Science grant EF 1241885 (subaward 13-0632).

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